ABSTRACT

A method of growing quaternary epitaxial films having the formula YCZN wherein Y is a Group IV element and Z is a Group III element at temperatures in the range 550 – 750°C is provided. In the method, a gaseous flux of precursor H_3YCN and a vapor flux of Z atoms are introduced into a gas-source molecular beam epitaxial (GSMBE) chamber where they combine to form thin film of YCZN on the substrate. Preferred substrates are silicon, silicon carbide and AlN/silicon structures. Epitaxial thin film SiCAlN and GeCAlN are provided. Bandgap engineering may be achieved by the method by adjusting reaction parameters of the GSMBE process and the relative concentrations of the constituents of the quaternary alloy films. Semiconductor devices produced by the present method have bandgaps from about 2 eV to about 6 eV and exhibit a spectral range from visible to ultraviolet which makes them useful for a variety of optoelectronic and microelectronic applications. Large-area substrates for growth of conventional Group III nitrides and compounds are produced by SiCAlN deposited on large-diameter silicon wafers. The quaternary compounds, especially the boron containing compounds, exhibit extreme hardness. These quaternary compounds are radiation resistant and may be used in space exploration.